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(71) Applicant
Tesel PLC (United Kingdom),
P. O. Box No 13, Houndmills Road, Basingstoke,
Hants RG21 1AJ

(72) Inventors
Timothy George Boxell,
David Easton Stoddart

(74) Agent and/or Address for Service
Carpmaels & Ransford, 43 Bloomsbury Square,
London WC1A 2RA

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US 3677080

(58) Field of search
E1F
Selected US specifications from IPC sub-class E21B

(54) Improvements in downhole tools

(57) A tool for use downhole for collecting material samples, e.g. formation fluid, includes an inlet (24) for allowing material into the tool, storage chambers for storing material to be brought to the surface, a passage (34) for conducting material from the inlet (24) to the storage chambers and a by-pass passage (33) for by-passing the storage chambers such that material is able to flow from the inlet (24) through the by-pass (33) and out of the tool (10) through an outlet (44). A pump (41, 42) is provided for pumping material through the by-pass passage (33) and a valve (35) is provided for controlling flow of material to the storage chambers.

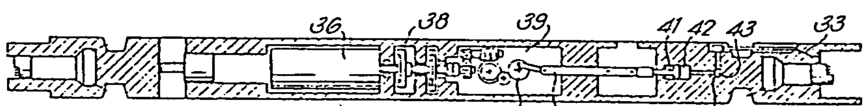
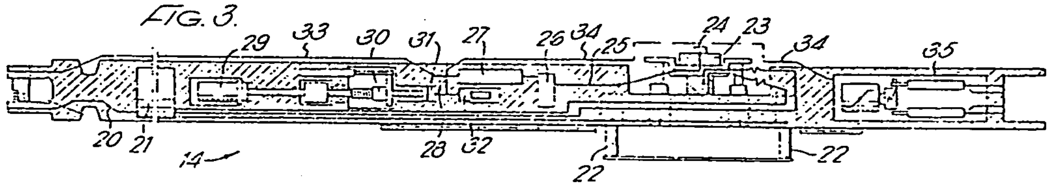


FIG. 2.

FIG. 3.



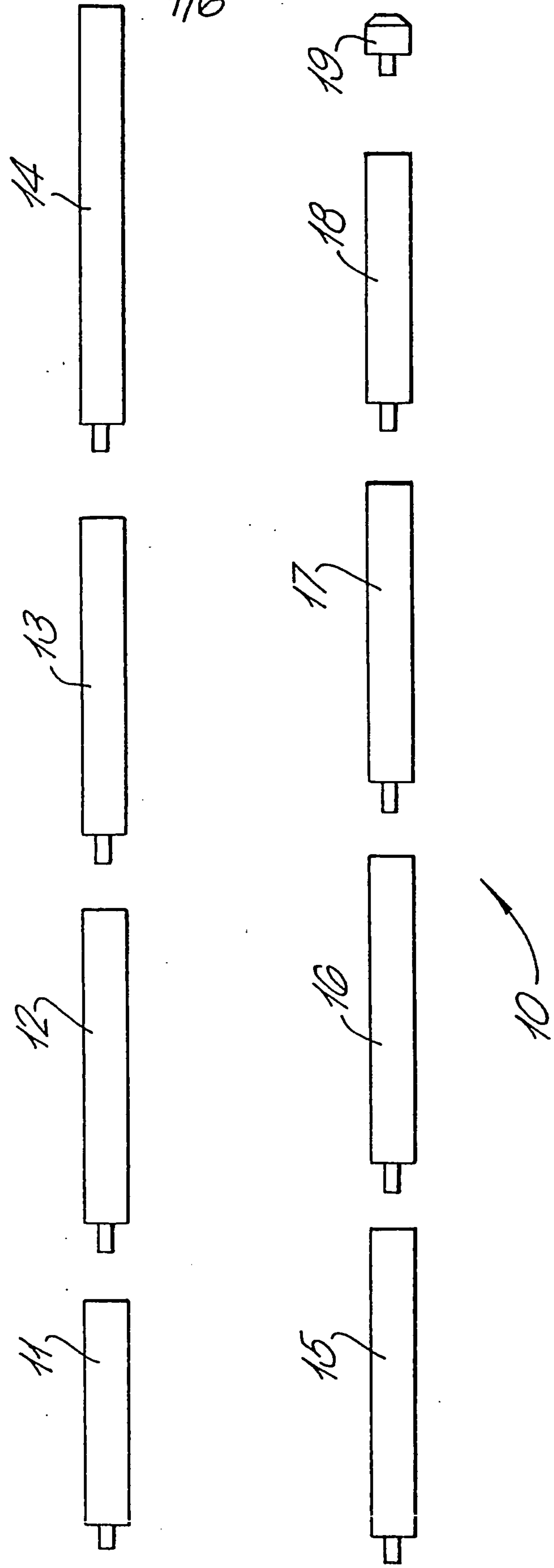


FIG. 1.

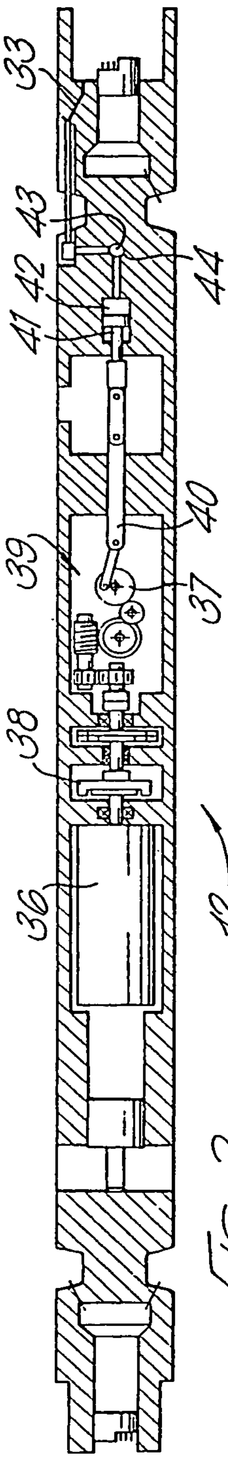

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FIG. 2

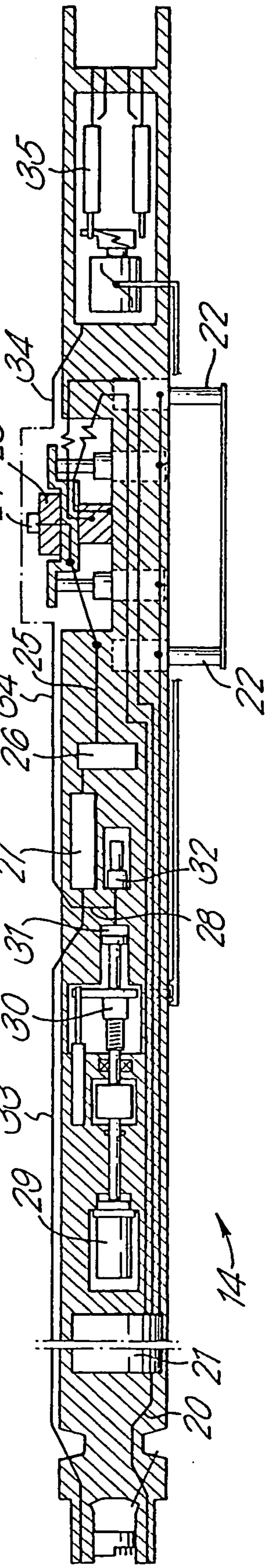
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FIG. 3

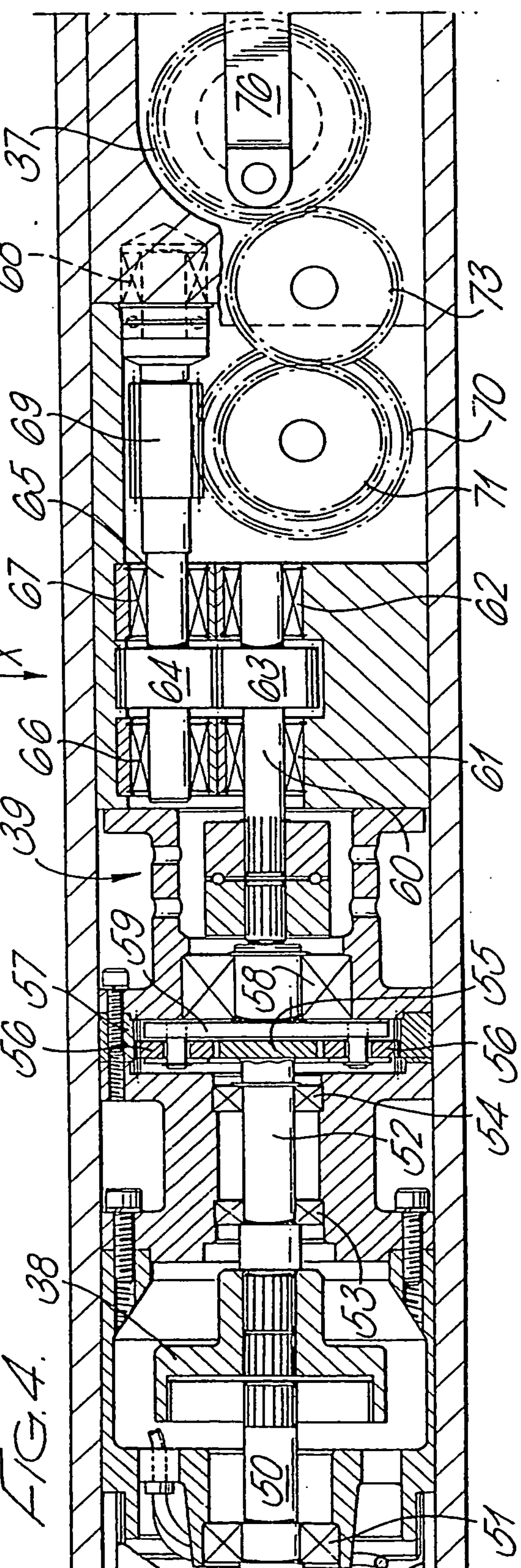
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FIG. 4.

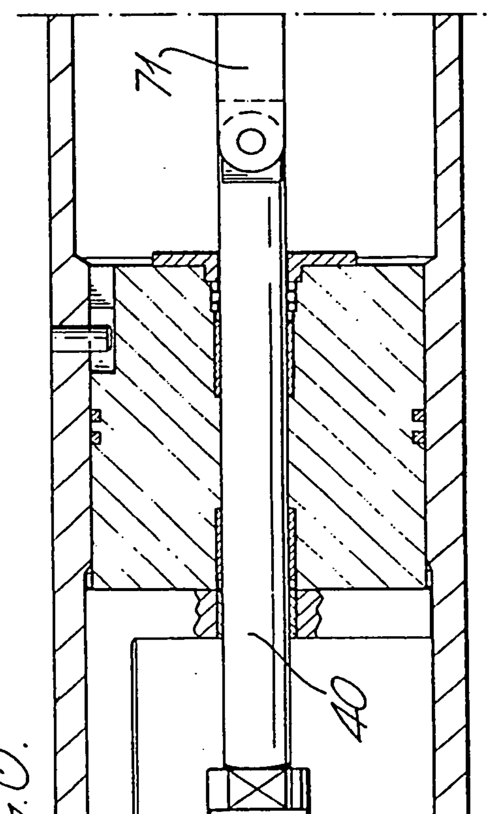
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FIG. 5.

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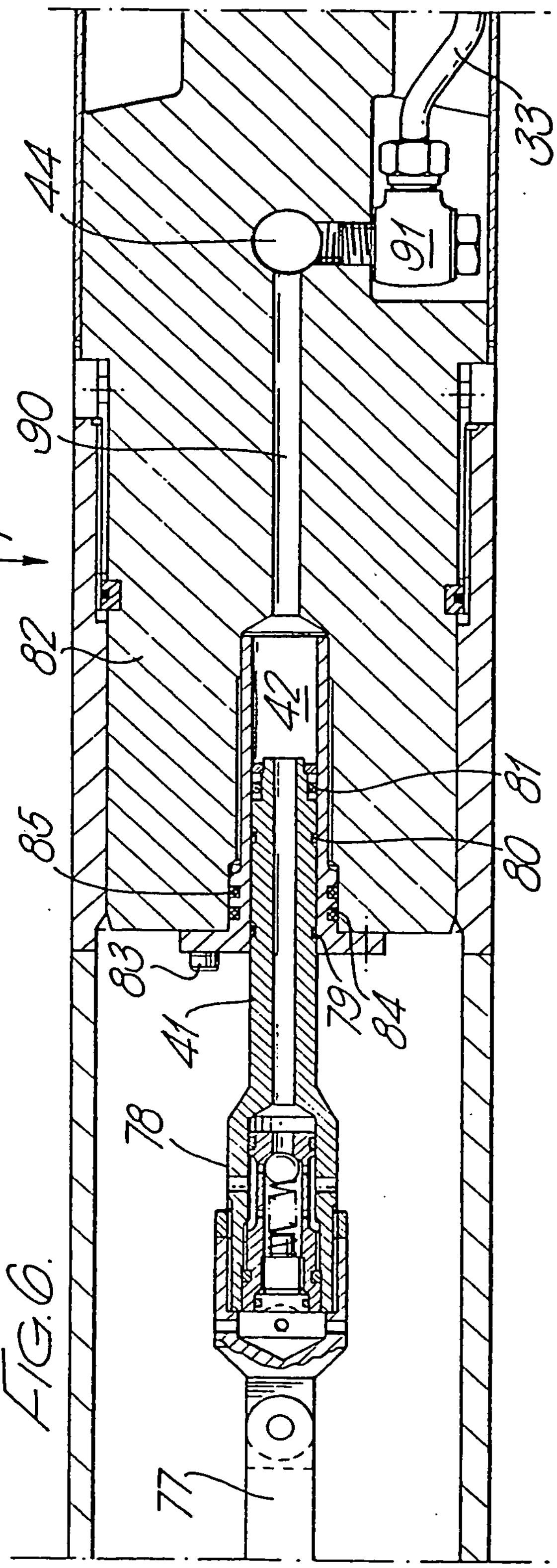

FIG. 6.

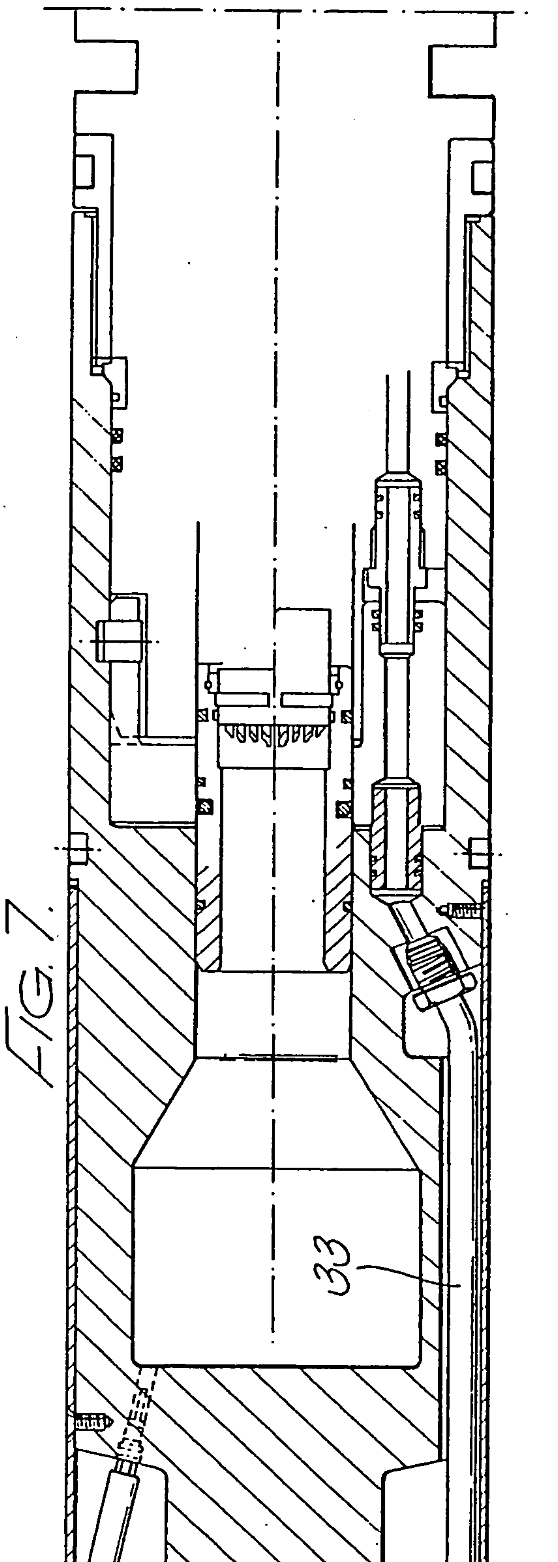

FIG. 7.

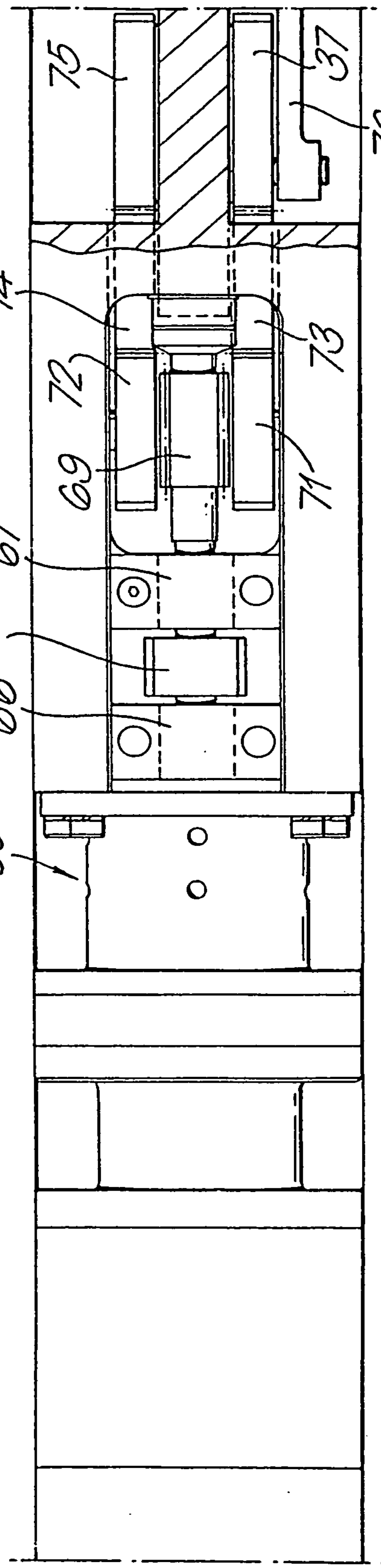

FIG. 8.

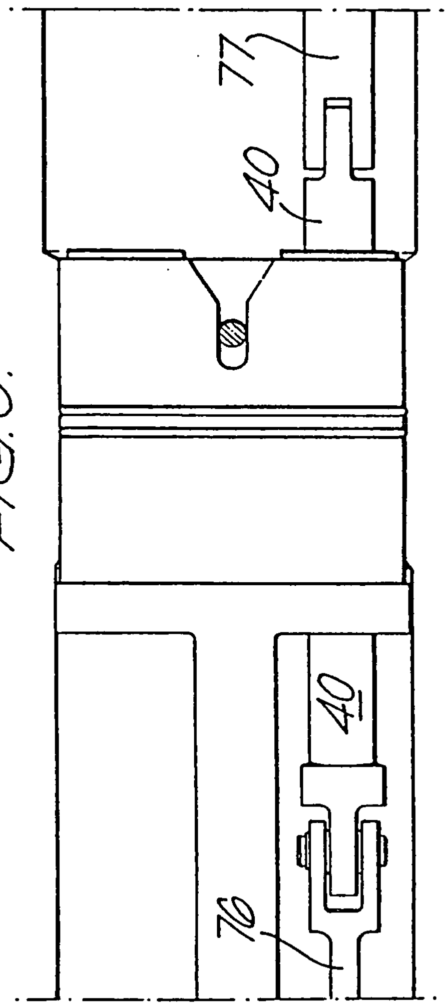

FIG. 9.

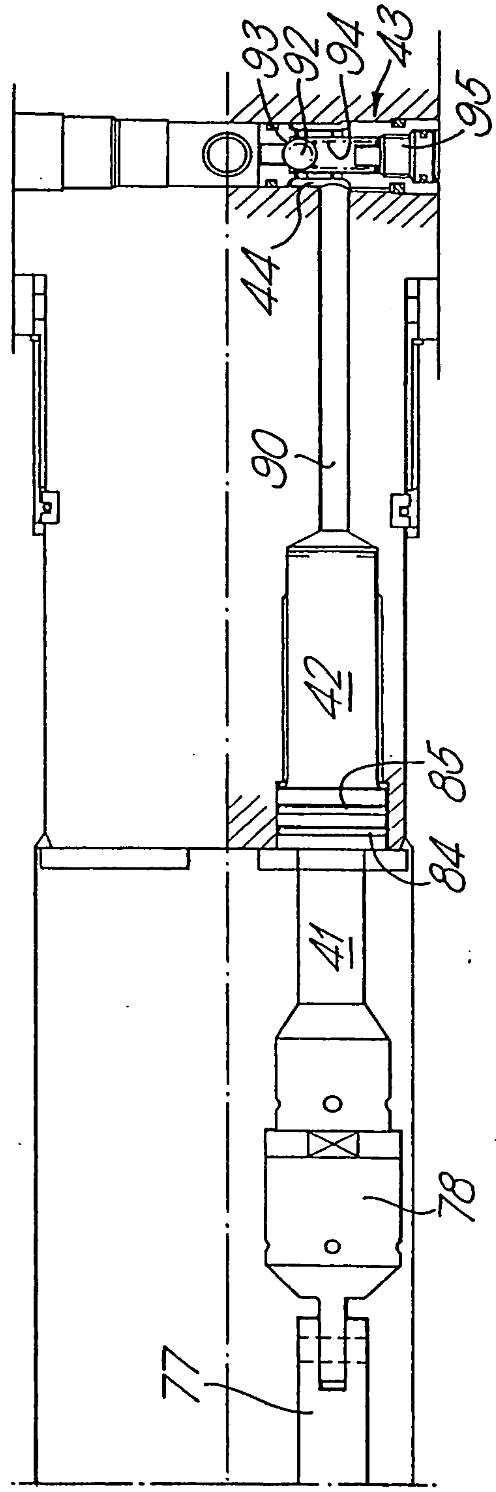

FIG. 10.

SPECIFICATION

Improvements in downhole t ls

The invention relates to tools for use in testing material surrounding a borehole.

Tools have been in existence for some time which are capable of taking samples of fluid from the formation surrounding a bore-hole, such tools including a probe for entering the formation and allowing fluid from the formation into the tool, and one or more storage chambers for collecting samples of formation fluid.

In known tools, before a sample is actually taken of a formation, a pretest procedure is generally taken. Such a pretest procedure involves drawing some formation fluid into a pretest chamber and observing the pressure characteristics of the operation. This gives an idea of the nature of the formation fluid and whether taking a sample is worthwhile. Such pretest procedures are, however, not entirely effective since they are unable to monitor continuously the nature of the formation fluid.

Hereinafter, the term "material" will be used to refer to "formation fluid" where the context is appropriate.

According to the invention, there is provided a tool for use downhole for collecting material samples, which tool includes an inlet for allowing material into the tool, storage means for storing material to be brought to the surface, first passage means for conducting material from the inlet means to the storage means, by-pass passage means for by-passing the storage means such that material is able to flow from the inlet means through the by-pass passage means and out of the tool through outlet means, pump means for pumping material through the by-pass passage means and valve means for controlling flow of material to the storage means.

The pump means may include at least one piston and cylinder assembly. There may be more than one, for example two or four piston and cylinder assemblies.

The piston of the or each piston and cylinder assembly may be reciprocated by connecting rod means driven by a rotating wheel. The rotating wheel may be driven by an electric motor or possibly a hydraulic motor.

The motor may drive the rotating wheel via a centrifugal clutch.

In the preferred case where the tool includes a pair of piston and cylinder assemblies, the piston of one assembly is preferably moving out of the associated cylinder when the piston of the other assembly is moving into the associated cylinder and non-return valve means are preferably provided such that there is a continuous pumping action.

The tool preferably includes a pretest cylinder and pretest piston movable therein connected to said inlet means, and a pressure transducer for monitoring material pressure characteristics as material is drawn into the pretest cylinder.

The tool preferably includes a resistivity cell included in the passage means leading from the inlet means.

The storage means may include a plurality, for example four, storage chambers. The valve means for controlling flow of material to the storage means preferably allows material to flow to one storage chamber only at any one time.

By way of example, one embodiment of a tool according to the invention will now be described with reference to and as shown in the accompanying drawings, in which:-

Figure 1 is a schematic diagram of the tool layout;

Figure 2 is a diagrammatic view of a formation flushing module;

Figure 3 is a diagrammatic view of a packer module;

Figure 4 is a view partly in section of a portion of the flushing module;

Figure 5 is a view partly in section of a portion of the flushing module adjacent to the portion shown in Figure 4;

Figure 6 is a view partly in section of a further portion of the flushing module adjoining the portion shown in Figure 5;

Figure 7 is a view partly in section of a still further portion of the flushing module adjoining that portion shown in Figure 6;

Figure 8 is a view in a direction X in Figure 4 showing part only of the detail of Figure 4;

Figure 9 is a view showing detail in part only of the portion of the flushing module shown in Figure 5 from the same direction as Figure 8; and

Figure 10 is a view showing part only of the detail of the portion of the flushing module shown in Figure 6 in a direction Y in Figure 6.

Figure 1 shows schematically the layout of a tool 10 according to the invention. The tool 10 is of necessity long and of small enough diameter to be movable in a drilled hole.

At one end of the tool 10 is an electronics module 11 containing the necessary control circuitry for the tool, and which is connected by appropriate cabling to the surface, in use. Next to the electronics module 11 is a formation flushing section 12 which will be described in more detail later. Next to the formation flushing module 12 is a hydraulic power module 13, then a packer module 14, then four separate sample chambers 15, 16, 17 and 18 and finally an end cap 19.

Figures 2 and 3 show diagrammaticallydetails of the formation flushing module 12 and the packer module 14 respectively.

The packer module 14 is supplied with pressurised hydraulic fluid through a hydraulic line 20 from the hydraulic power module 13. The hydraulic line 20 leads to a valve block 21 from which three hydraulic lines lead to operate back-up jacks 22, packer 23 and a probe 24.

The probe when extended has an opening through which material from outside the tool 10 can enter the probe 24 and thereby the tool 10. Material enters through a material flow line 25 which leads to an equalising valve 26 and a resistivity cell 27.

The line 25 branches three ways downstream of the resistivity cell 27, one branch 28 leading to a pretest assembly including a pretest drive motor 29, a ball screw assembly 30, a pretest piston and cylinder assembly 31 and a pressure transducer 32 (ascertaining material characteristics by examining pressure characteristics as a pretest piston is drawn along a pretest cylinder is a known test), a second branch 33 leading to the formation flushing module 12 and a third branch 34 leading to a sample valve assembly 35.

Figure 2 shows diagrammatically the formation flushing module which will be described in more detail with reference to Figures 4 to 10.

With reference to Figure 2, a motor 36 drives a drive wheel 37 via a centrifugal clutch 38 and a gear box 39. The drive wheel 37 imparts a reciprocating motion to connecting rod 40 to reciprocate a piston 41 in a pumping cylinder 42. Although only one connecting rod 40, piston 41 and pumping cylinder 42 is shown in Figure 2, the formation flushing module has two such assemblies arranged in parallel, both assemblies being driven by an associated drive wheel.

The piston 41 draws material from the line 33 through non-return valve 43 and into the cylinder 42. Upon the return stroke, the material in the cylinder 42 is ejected through the transverse channel 44 out of the tool 10.

In initial operation, the sample valve 35 is maintained closed, and formation material is flushed through the tool by the formation flushing module 12. While flushing material through the tool, the material passes through the resistivity cell 27 which measures the resistivity of material flowing along the line 25, and thereby provides an indication of the nature of the material. The resistivity cell 27 provides measurements of resistivity which are fed back to the surface for analysis and, based on measurements, a decision can be reached as to when a pretest operation should be started. As has been stated before, the pretest is a well known preliminary in formation testing and provides an indication of the nature of the material about to be sampled. When it is decided that a sample is to be taken, the sample valve 35 is opened and material flows down the line 34 to a selected one of the sample chambers.

The detailed operation of the formation flushing module 12 will now be described with reference to Figures 4 to 10.

Reference numerals already used in Figures 2 and 3 will be repeated in Figures 4 to 10.

Figures 4 to 7 show the formation flushing module 12 partly in section and Figures 8, 9 and 10 are plan views of the apparatus shown in Figures 4 to 7.

As stated previously, the formation flushing module mechanism is driven by an electric motor (not shown in Figure 4), the motor causing rotation of a shaft 50 mounted in bearings 51. In turn, the shaft 50 drives a further shaft 52 mounted in bearings 53 and 54 via the centrifugal clutch 38 already described.

The shaft 52 drives the gear box generally indicated at 39. The gear box 39 has an epicyclic gear train including a sun wheel 55 and planet wheels 56 engaged in an internally toothed ring gear 57. The planet gears 56 are rotatably mounted on a planet carrier 59 journalled in a bearing 58.

The planet carrier 59 drives a shaft 60 journalled in bearings 61 and 62 and carrying fixedly on it an externally toothed gear 63 which meshes with an adjacent externally toothed gear 64 mounted on a further shaft 65, the shaft 65 being journalled in bearings 66, 67 and 68.

The shaft 65 has fixedly mounted on it a worm gear 69 which meshes with an externally toothed gear wheel 70. The gear wheel 70 is fixed for rotation with a pair of externally toothed side wheels 71 and 72 which side wheels mesh with associated externally toothed intermediate wheels 73 and 74. The intermediate wheels 73 and 74 mesh in turn respectively with the drive wheel 37 described already and a sister drive wheel 75.

The drive wheels 37 and 75 have mounted eccentrically thereon connecting rods, only the connecting rod mounted on drive wheel 37 being shown in the drawings, the latter carrying reference numeral 76. The drive wheels 37 and 75 drive two parallel piston and cylinder assemblies, only one of which (that driven by drive wheel 37) will now be described.

The connecting rod 76 is pivotally connected to the connecting rod 40 already described which in turn is pivotally connected to a link 77. The link 77 is pivotally connected to the piston 41 previously described, the piston 41 including a pressure relief assembly 78 which will not be described in detail. The piston 41 engages the cylinder 42 previously described, seals between the piston 41 and the cylinder 42 being achieved through a series of O-rings 79, 80 and 81. The cylinder 42 is mounted in a block 82 by means of bolts 83, a seal between the cylinder 42 and the block 82 being achieved through further O-rings 84 and 85.

From the cylinder 42 leads a passage 90 which passage 90 in turn leads to the transverse passage 44 previously described. In turn, the transverse passage 44 is connected centrally via a coupling 91 to the line 33 previously described.

The transverse passageway 44 includes the non-return valve 43 previously described, a sister non-return valve (not shown) being provided for the other piston and cylinder assembly.

The non-return valve 43 includes a pair of spaced apart non-return valves, one of which is shown in Figure 10. A ball 92 is biased against a seat 93 by a spring 94 to allow material to be drawn from the line 33 through the line 90 into the cylinder 42 when the piston 41 is withdrawn. Upon return of the piston 41 into the cylinder 42, the ball 92 is forced against the seat 93 to prevent return of material to the line 33. In a similar fashion but in reverse, a second non-return valve 95 prevents material from outside of the tool flowing into line 90 when the piston 41 is being withdrawn from the cylinder 42 but when the piston 41 returns into the cylinder 42, material is allowed to leave the tool via the non-return valve 95. The material exits into

the borehole fluid.

Thus, it will be appreciated that reciprocation of the piston 41 in the cylinder 42 continuously draws material from the formation surrounding the tool through the line 33 and out of the tool. As has been described previously, there are two parallel piston and cylinder assemblies and when one piston is withdrawn from the associated cylinder, the other piston is engaged within the associated cylinder thus providing a continuous pumping action.

Details of the tool shown in Figures 4 to 10 which do not form part of the flushing system will not be described.

The advantage of this embodiment of the invention is that a convenient system is provided for continuous flushing of formation material through the tool while characteristics of that material are monitored, for example by the resistivity cell 27. The flushing can continue uninterrupted until promising information about the formation material is provided, and it is decided to take a sample.

CLAIMS

1. A tool for use downhole for collecting material samples, which tool includes an inlet for allowing material into the tool, storage means for storing material to be brought to the surface, first passage means for conducting material from the inlet means to the storage means, by-pass passage means for by-passing the storage means such that material is able to flow from the inlet means through the by-pass passage means and out of the tool through outlet means, pump means for pumping material through the by-pass passage means and valve means for controlling flow of material to the storage means.

2. A tool as claimed in Claim 1 wherein the pump means includes at least one piston and cylinder assembly.

3. A tool as claimed in Claim 2 wherein the piston of the or each piston and cylinder assembly is reciprocated by connecting rod means driven by a rotating wheel.

4. A tool as claimed in Claim 3 wherein the rotating wheel is driven by an electric motor.

5. A tool as claimed in Claim 3 wherein the rotating wheel is driven by a hydraulic motor.

6. A tool as claimed in any one of Claims 3 to 5 wherein the motor drives the rotating wheel via a centrifugal clutch.

7. A tool as claimed in any one of Claims 2 to 6 wherein the pump includes a pair of piston and cylinder assemblies.

8. A tool as claimed in Claim 7 wherein the piston of one assembly moves out of the associated cylinder when the piston of the other assembly is moving in to the associated cylinder.

9. A tool as claimed in any one of Claims 2 to 8 comprising non-r turn valve means for providing a continuous pumping action.

10. A tool as claimed in any preceding Claim including a pretest cylinder and pretest piston movable therein connected to said inlet means and a pressure transducer for monitoring material pressure characteristics as material is drawn into the pretest cylinder.

11. A tool as claimed in any preceding Claim including a resistivity cell included in the passage means leading from the inlet means.

12. A tool as claimed in any preceding Claim wherein the storage means includes a plurality of storage chambers.

13. A tool as claimed in Claim 12 wherein the valve means for controlling flow of material to the storage means allows material to flow to one storage chamber only at any one time.

14. A tool substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

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